original investigations. He wrote a "Book of Almanacs," with an Index of Reference, by which the Almanac may be formed for every year up to A.D. 2000, with means of finding the day of the new moon from B.C. 2000 to A.D. 2000. He was also secretary and member of the Council of the Royal Astronomical Society for many years. He and his son, George De Morgan, also a mathematician of great promise, whose untimely death will be remembered, took the most active part in the foundation of the London Mathematical Society, of which he was the first president. Prof. De Morgan will be buried on Thursday, the 23rd, at Kensal Green, but his memory will long be cherished among a large circle of attached and admiring friends.

ARTHUR C. RANYARD

PAPERS ON IRON AND STEEL

IV.—THE BESSEMER PROCESS (*continued*).

THE magnificent shower of sparks which accompanies the turning over of the converter is easily explained. The blast has, of course, to be maintained during this turning over, until the whole of the melted material is clear of the openings through which the blast is forced. As these cover a considerable area at the bottom of the converter, the edge of the liquid passes them successively, and at the moment of thus passing the blast cuts the surface of the melted matter almost horizontally. But what is this melted matter? It is a pool of iron, on the top of which is floating a thick scum of silicate of iron, &c.—the "cinder." I use the term "silicate of iron" only in an approximate sense, as I doubt whether the silica is completely oxidised.

My reasons for doubting it are that the particles which are driven out of the converter by the blast are, to some extent, explosive, they are seen to burst with brilliant coruscations which are partly due to further oxidation; and when the granules which shower upon the floor are examined in the microscope, they present a very curious appearance. They are minute hollow spherules, miniature bomb-shells, varying considerably in diameter from one-tenth of an inch to one-fiftieth and less in diameter. The largest are more or less broken, commonly of a basin shape, shown in Figs 1 and 2.*

The smaller spherules are for the most part perforated. My friend, Mr. Joseph Bragg, who has carefully examined these, and to whom I am indebted for the drawings from which the engravings are copied, says, "I can hardly satisfy myself that any are quite without apertures, though some have no distinct round holes as most have, but in these cases there are minute openings between and under the welded scales or plates which often cover the spherules, giving them a rough surface." Conglomerate groups of these spherules, such as are shown in Figs. 3* and 4, are very common, and some are attached to irregular lumps of cinder, as shown by the right-hand fragment on Fig. 3. A few are pear-shaped (see Fig. 4). On the right of these pear-shaped specimens are shown some of the smaller spherules in which the perforations are less evident. In the smallest, as the agglomerated and attached specimens (Fig. 3), the perforations are very obscure or doubtful.

Sir Samuel Baker, in his "Nile Tributaries of Abyssinia," describes some natural products due to a similar action on a vastly larger scale, viz., the volcanic eruption of a flood of gaseous matter through fused silicates. He says, "Rows of broken hills, all of volcanic origin, broke the flat plain. Conical tumuli of volcanic slag here and there rose to the height of several hundred feet. We entered a dead level plain of orange-coloured sand, surrounded by pyramidal hills; the surface was strewn with objects resembling cannon shot and grape of all sizes, from a 32-pounder downwards; the spot looked like the old battle-fields of some infernal region. . . . I dismounted to examine the Satanic bombs and cannon shot. Many of them were as perfectly round as though cast in a mould, others were egg-shaped, and all were hollow. With some difficulty I broke them, and found them to contain a bright red sand; they were, in fact, volcanic bombs that had been formed by the ejection of molten lava to a great height from active volcanoes; these had become globular in falling, and having cooled before they reached the earth, they retained their forms as hard spherical bodies precisely resembling cannon shot. The exterior was brown, *and appeared rich in iron*. The smaller specimens were the more perfect spheres, as they had cooled quickly, but many of the heavier masses had evidently reached the earth when only half solidified, and had collapsed in falling. The sandy plain was covered with such vestiges of volcanic action, and the infernal bombs lay as imperishable relics of a hailstorm such as may have destroyed Sodom and Gomorrah." To a Lilliputian traveller about an inch and a quarter high the floor of a Bessemer shop would present about the same aspect as this volcanic plain presented to Sir Samuel Baker, and would appear on about the same scale relative to the traveller's own dimensions.

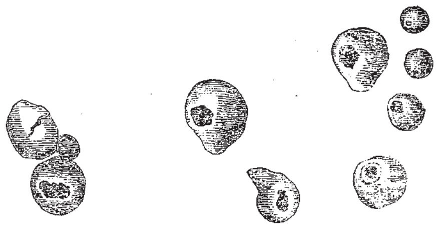

FIG. 4.

It may have been remarked that in the above I have never used the word "slag," which in chemical works is usually applied to the separated silicate of iron, &c., however it may have been separated. I have called it "cinder," in accordance with the nomenclature of the workshop, for in the use of these terms, slag and cinder, the workshop is more learned than the University, even in the matter of etymologies, which occupies so absorbing an amount of University attention.

Whenever the silicate is separated by fusion or the direct action of the fire he calls it "cinder," when it is squeezed out from a bloom or pile by the blows of the hammer he calls it "slag." Now the Scandinavian name of *fire* refuse or dross is *sinner*, the German for the same is *sinter*. The Scandinavian for a blow is *slag*, the German *schlag*. I have observed with much interest the constancy with which the workman adheres to the strictly etymological signification of these words, while learned writers utterly confound them. Of course the workmen are unacquainted with their origin, nor have I ever seen their distinctive etymologies pointed out by anybody else. They afford an interesting illustration of the technical continuity of modern English with its ancient Scandinavian basis. Our metal workers, like our sailors, still speak the strong tongue of the old Norseman. There are scientific as well as etymological reasons for the distinction between cinder and slag, and therefore I adopt the workmen's phraseology.

W. MATTIEU WILLIAMS

SCIENCE IN GOVERNMENT WORKSHOPS

THERE seems to be a singular antagonism between science and officialism. The Government has undertaken more than one special manufacture, and not without a certain measure of success, but even the best of Government factories are tainted with some perverse defiance of scientific principles. Why this should be is too large a question for present discussion, but the fact is beyond doubt. Take, for example, one of the most effective seats of national manufacture—the small-arm factory at Enfield, which is under the command of an officer who may fairly be credited with scientific intelligence. You will see there a considerable amount of what may be called imported science. Outside inventions in machinery, in rifle barrels, in locks, in breech-actions, and other branches of the work, have been appreciated, adopted, and improved, and this is so far good. The Snider is a very clever makeshift, and perhaps as good a converted rifle as could have been made out of the old Enfield. The projected Henry-Martini, again, has an excellent breech-action, though not quite the best that might have been selected. Its barrel is on a good and tried pattern, although one that has not very successfully competed with the Metford. In these respects, the design cannot be called unscientific, but it is said that one essential element of the new rifle—the sighting—if not absolutely left to be fixed by tradition and routine, will be in principle little better than the worthless sighting of the old Enfield. If a crack shot were offered the choice between a first-rate barrel with clumsy and unscientific sights and an inferior barrel fitted with perfect sights, he would certainly prefer to enter into a competition with the latter weapon. Errors from defective aim are, as a rule, much larger than those due to imperfections of rifling, and to fit a first-rate weapon with bad sights is to throw away nearly all the skill and money which has been expended upon it. This is just what the people at Enfield are doing now, and all for want of familiarity with one of the simplest maxims of geometrical science. When a mathematician, an astronomer, an engineer, or even a superior artisan, wishes to determine with accuracy the position of a point, he almost invariably does it by setting off its distance from each of a pair of rectangular co-ordinate axes. In very special cases and for very special reasons the advanced geometrician will occasionally employ oblique instead of rectangular axes; but whenever it is practicable, whether he is dealing with linear or angular measure, he uses as a matter of course rectangular axes. In a case where he has to measure independent variations in horizontal and vertical directions, he would think it simply absurd to refer the position of a point to any other than a pair of horizontal and vertical axes of co-ordinates. Thus the astronomer has his co-ordinates of azimuth and altitude, of latitude and longitude, the builder works with his plummet and square, and the most simple-minded carpenter, who wished a nail put in a particular spot on a wall, would order it to be driven in at so many feet from the floor, and so many feet from the side of the room. This elementary scientific method has in fact descended to so low a stratum of intelligent society that most people have assimilated it as if by instinct, and would open their eyes rather widely if they were told that when they practised it they were obeying the dictates of science. And yet, strange as it may seem, this extremely elementary, almost axiomatic, idea of rectangular co-ordinates, has not yet penetrated to the Government factory at Enfield. Consider what the sights of a rifle are for. In the simplest case, when you are aiming at an object the distance of which is known, and when there is no wind, you have nothing to do but to adjust the sights to the right elevation, and align them upon the object. But if your first shot falls low or high, or if you want to hit another object at a different distance, you must do one of two things, either slide your backsight up or down or else take a fuller or finer sight. In other words, you must correct the error in elevation, either by mechanical adjustment or eye-adjustment in the vertical direction. Practically, large and occasional changes are made by mechanical adjustment; small and frequent changes by eye-adjustment. So again, if there is wind to allow for, you must either give the sights an apparatus for lateral adjustment (which, of course, would be quite inadmissible in a military arm), or, you must make the necessary allowances by eye-adjustment in the horizontal direction. The occasions which require vertical and horizontal corrections are quite independent of each other, the one class being functions mainly of distance, and the other of lateral wind. This is, therefore, precisely the case where the position of the sight should be referred to vertical and horizontal lines.

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* Figs 1, 2, and 3 will be found in last week's number of NATURE, p. 389

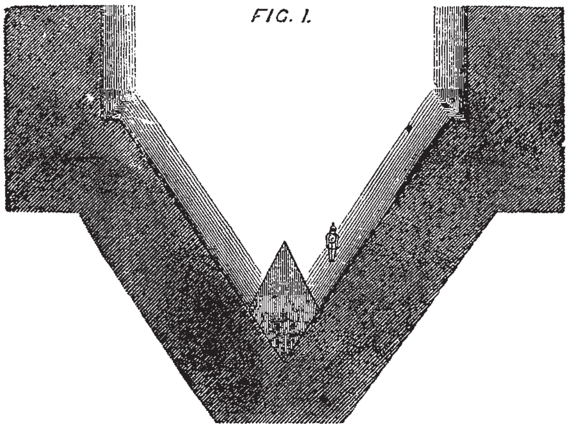


FIG. 1.

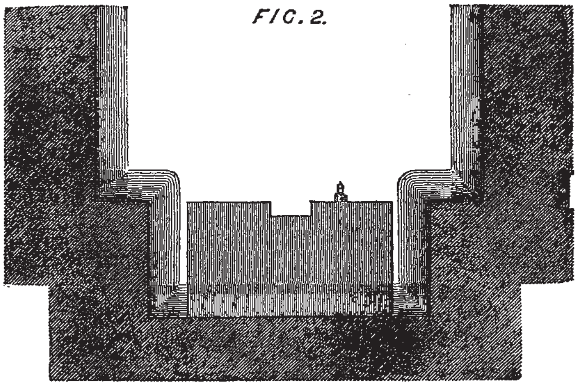


FIG. 2.

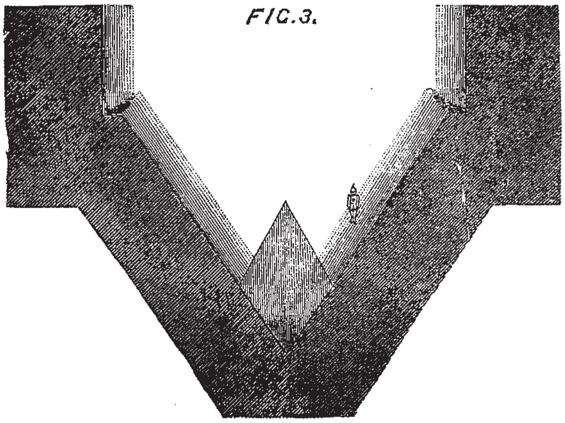
Instead of doing this, our Government manufacturers give you a backsight, bounded by two oblique lines at a certain inclination to the vertical, and they provide you with a foresight, bounded by two other oblique lines at a different inclination to the vertical. When they indulge in a great effort of imagination they sometimes dream of getting rid of the oblique lines on the backsight, still leaving the foresight as bad as ever. Anything more perversely unscientific can scarcely be imagined, though we daresay it will be stoutly defended on the plea that it is the same venerable system which contributed to the non-efficiency of Brown Bess.

To any mechanician, however humble, it must be quite clear that both backsight and foresight ought to be bounded by horizontal and vertical lines. And here we might close the subject but for the stupendous power developed by the military mind, of pooh-poohing suggestions which have only science and reason to recommend them. "Extremely ingenious and scientific, no doubt," our soldier critic may say, "but shows a woeful ignorance of the practical conditions of the problem. You see our recruits are not philosophers, but rough fellows, and we must give them something easy to understand and handle, and capable of bearing rough usage. Experience has shown that there is nothing like the old V backsight and knife-edge foresight, with which the British soldier can go anywhere and do anything, &c. &c. You scientific people always forget to look at the practical side of things."

Now that is just what scientific men don't forget. No man can be really practical unless he is also in his measure scientific. But in this matter of sights it may be worth while to follow the advice of our imaginary soldier, and look more minutely at the practical side of the question. What is the test of a good sight? Obviously the best sight is that which enables the rifleman most easily to judge whether two successive aims are alike, or if they differ, to say in what direction and to what extent they do so. For this reason the soldier is taught to discriminate between fine sights, full sights, and half sights, according to the quantity of foresight which he allows to be visible above the bottom of the V. What he sees is an irregular lozenge, and the accuracy of his shooting, so far as elevation is concerned, depends upon his judging with perfect exactness the length of the vertical diagonal of this lozenge. Again, if wind has to be allowed for, he must fix in his mind the apparent distance at which the tip of the foresight should be seen on the right or left of the object. The difficulty of these eye-adjustments is enormously increased by giving him nothing but inclined datum lines from which to estimate. The language in which it is customary at Hythe to inculcate the method of making allowance for wind, curiously illustrates the absurdity of the received sight-pattern. The recruit is told that he must "aim at nothing to hit something," a phrase really very happy as a description of the difficulty of estimating at the same time elevation and lateral allowance with a Government rifle. The most practised shots find it by no means easy to vary their horizontal allowance for wind without in some degree altering their elevation, and all this difficulty is quite gratuitous.

The true test of the value of a system of sighting is of course to be applied rifle in hand, but our pictures will show tolerably well what the result of such a test would be. Figure 1 is what a man sees when he takes an aim with the present military sights. It is meant for a half-sight, the lozenge in the middle being the portion of foresight visible, and the shading being as near a representation as we can give of the haze which always more or less blurs the outline of the backsight. We have supposed a little wind, and the object is therefore seen on one side of the sight, and is as nearly level with the tip of it as it can be brought without the guidance of any horizontal line. Now suppose the rifleman finds that sight correct, and wishes to shoot down a second enemy at the same range and under the same conditions. He will try to take just the same sort of aim again, and Fig. 3 is a pretty good approach to it. Probably the reader will have to look backwards and forwards rather carefully before he can judge whether there is any, and how much, discrepancy between Figs. 1 and 3, and if (as would be the case in actual practice) Fig. 1 had gone out of existence say only a few minutes before Fig. 3 was looked at, we doubt very much whether the error would be large enough to be discerned at all, and we are sure that its amount would not be correctly estimated.

FIG. 3.

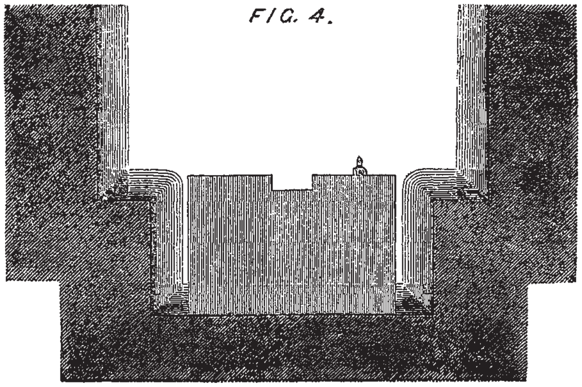


Now, take the case of rectangular sights such as are drawn in Fig. 2. In this, as in Fig. 1, the elevation is supposed to be normal—that is, with the horizontal top of the foresight level with the top of the backsight below the haze. The allowance for wind is exactly the same as in Fig. 1, and its amount may be fixed in the memory by noting that the object is about twice as far from the outer edge of the foresight as it is from the little rectangular notch which marks the middle of it. Having looked at this, it would be quite possible to go away for a day, and then return and look at Fig. 4, and see at once that this latter differs from the former by being a considerably higher sight with a much larger allowance for wind. No error anything like as gross as this could be made even by the poorest shot in two successive aims. And yet the real differences in elevation and horizontal allowance between Figs. 2 and 4 are not larger than those between Figs. 1 and 3, which cannot be detected or remembered without the greatest difficulty. And this is the result simply of substituting rectangular for oblique sights.

"All very pretty," says our soldier, again, "but how are you to get such a sight as you have drawn, on a rifle meant to carry a bayonet and to be used in war?"

We are fortunately able to answer this question. Figs. 2 and 4 are taken from the actual sights of a rifle prepared as follows—A London armoury rifle of Government pattern was taken; the knife-edge of the foresight was filed clean off, leaving the block, and then a small rectangular groove was filed longitudinally in the middle of the block, thus leaving the foresight less liable to injury than before. Then the sliding-bar was turned upside down, and a square notch filed instead of the triangular V.

FIG. 4.



The rifle so altered was rather fitter for rough work than before, and it was possible to aim with it and to make exact allowance for wind into the bargain. The use of it, too, was incomparably easier for a recruit to learn. We may add that the result of actual shooting with it has been quite conclusive in its favour. And yet the beautiful and expensive Henry-Martini is now being turned out with sights which neutralise one half of the accuracy of the weapon by making accuracy of aim impossible.

It will cost at least 1,000,000*l*. to arm our troops with Henry-Martinis in lieu of Sniders, and on a moderate computation one-third of the gain in accuracy (which may be represented by one-third of the cost) is utterly thrown away by the defective sighting.

If these things were not ascertained facts, it would be hard to believe them possible. Is it even yet too late to stop the mischief? G. W. H.